tions of aquatic insects are concerned with the respiratory system.

Current is an important factor of aquatic environments which finds its terrestrial counterpart in winds. That it is a very important factor is shown by the numerous devices aquatic insects have to keep their position and it varies from nothing in puddles to the rush of Niagara.

Food is a factor which is always both important and variable. It is, however, a secondary factor in that, whatever the food habits of the insects may be, the analysis always leads us back to plants which have their own primary relations to the organic factors of the environment.

Enemies are also important and variable. The abundance or absence of fish in a pool will go a long way toward deciding whether mosquitoes will breed there or not.

Summarizing the factors of aquatic environments with respect to their effects upon the distribution of insects: Humidity is important only in the case of salty water and where there is a great decay of humus as in peat bogs. Temperature is probably only slightly more important. Light is probably important chiefly on account of its influence upon vegetation, hence food. Oxygen would seem to be of great direct importance. It should be noted in this connection, however, that many of the insects which live in the water breathe atmospheric air. Finally, among the inorganic factors current is not only of direct importance but has an additional indirect effect through its influence upon the oxygen content of the water. The organic factors of food and enemies are, of course, of prime importance.

RELATIONS OF TRICHOPTERA TO THEIR ENVIRONMENT.

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Trichoptera are almost exclusively confined to aquatic environments during the larval and pupal stages. The larvæ of one species of Limnephilidæ is reported to live in mosses at the roots of trees but the group as a whole is typically aquatic. As far as I know, with but very few exceptions, they are confined to fresh water and are rarely, if ever, to be found in any but permanent fresh water bodies.

The larvæ of Trichoptera have the extremely interesting habit of protecting themselves by building some sort of a case in which to live. Their cases are of a great variety of form and structure, as will be pointed out later. Those larvæ which live in very swift streams usually fasten their cases to stones by means of silken threads. In the more quiet waters the larvæ crawl from place to place, dragging their cases with them. Pupation takes place in the larval case. When it is time for the adult to emerge, the pupæ come to the surface either by crawling or by swimming with their middle pair of legs. The middle legs of the pupæ possess hairs adapting them to this use.

It is very interesting to watch some of the Hydropsychids, which live in swift streams emerge. As soon as the pupa reaches the surface its skin splits down the back and the adult flies away, leaving the skin on the surface of the water. It is almost as though the pupa swam to the surface and immediately flew. For the most part the pupæ of those species which live in ponds and slow flowing streams, crawl to the surface or beyond and the adult takes some time to dry its wings before flying.

With the possible exception of the Hydropsychidæ, the larvæ seem to be vegetarians, many of them feeding on the slime and decaying leaves found on the bottom. Even some of these will not refuse pieces of meat and it is believed that the net-building *Hydropsyche* at least are almost entirely carnivorous. The adults have rudimentary mouthparts and as far as is known they do not feed.

Usually both larvæ and pupæ breathe by means of tracheal gills. Some, however, lack gills and breathe through the skin. In my opinion there is little relation between distribution and the amount of oxygen in the water, as is indicated by the following experiments:

It has been pointed out that swift streams tend to be well supplied with oxygen and there is a general feeling that animals from such environment are difficult to rear in ordinary aquaria. However, I have kept even a net-building *Hydropsyche* for a week or more in mason jars.

In June last I also transferred about 50 of the snail-shell-like cases (*Helicopsyche annulicornis* Banks) from swift water to a quart jar and after about two weeks adults emerged from most of them. Some of these adults mated, laid eggs, and larvæ are now living (Jan., 1913) in a small dish containing less than one gill of water, which is merely renewed, never changed.

There is, however, a rather definite relation between the distribution of Trichoptera and the speed of the current, as is shown by the accompanying cut. The vertical divisions indicate the relative speed of the current and the black areas show the conditions in which the various cases (selected as typical forms) are found. The widths of the areas give an approximate idea of the relative abundance of the respective species in the various environments. Probably further study will make some changes in this diagram necessary, but I believe that it is correct in a general way at least. The upper case is that of a net-building *Hydropsyche;* it is typically found only in very strong currents but occasionally it does occur where the flow is not so rapid. They usually build their cases of sand or small pebbles, cemented together with silk and fastened on or between stones. The larvæ are very active, they are able to crawl over the stones and cling fast with their long pro-legs which are provided with strong hooks. The entrance of the case opens into a net with a canopy over it, built of very small pieces of twigs and leaves. The opening of the net faces the current. The pupa, upon leaving the case, crawls over the bottom for a short time, then shoots to the surface, where it immediately sheds its skin and takes flight. I have witnessed this a number of times. They undoubtedly obtain their food by means of the net.

The next species shown occurs with the net builder. It builds loose cases of small pebbles between or on stones in rapidly flowing water.

The next three species are found in water which has a fairly strong current but they do not occur in the swiftest streams where the two previously mentioned are at home. The larvæ do not fasten down their cases as do the two above mentioned.

The case of *Halesus argus* Harr. (the large one in the middle) consists of a tough inner portion surrounded by heavy water-soaked twigs and pieces of bark. The immature larvæ occasionally use pebbles also and those about to pupate normally do.

The cases of the other two species are made of sand and pebbles.

The lower (*Helicopsyche annulicornis* Banks) is formed of fine grains of sand of uniform size, cemented together with silk into the shape of a snail shell. As a matter of fact, it is said to have been described as a species of snail. The pupal cases are found attached to sticks, stones, and cases of larger Trichoptera.

The fifth species (*Psilotreta frontalis* Banks), found all the way from rather swift current to nearly still water, although quite common about Ramsey, is not recorded in Smith's list, nor even the family Odontoceridæ to which it belongs. The cases are made of small uniform grains of sand.

The next species is usually found in places having slightly less current, but never in absolutely still water. Their cases are somewhat similar to the previous one, although they taper more at the posterior end and are made of finer sand.

The wide flat sand case (*Molanna cinerea* Hagen) comes next in the series. It is not to be found in absolutely still water, although it does not occur where the current is even moderately strong.

The branched case is very different from the usual type of Trichoptera cases. There are several species differing slightly among themselves, but all apparently belonging to the genus *Polycentropus*. All but the upper tips of the cases are buried in the mud or sand. For the most part they are found where there is a very slight current, but they extend their distribution even up to the strong current and down to the absolutely still water. Those in the slight current of streams are built of sand, while those in the still water of ponds use very fine pieces of vegetable matter. The cases of some species are straight, others are branched as shown; some are of uniform diameter while others have enlargements, forming cells in which the larva rests, but all are imbedded in the bottom. Where the mud is deep the cases are much longer than where there is little or no mud.

We come now to those species which are typical of absolutely still water. The first, *Platycentropus maculipennis* Kolen. = *Halesus hostis* Hagen, it is true, occurs all the way up to rather strong current, but it becomes more abundant as the strength of the current decreases. Its case is made of bits of leaves—duck-weed being frequently used.

The last (*Phryganea interrupta* Say) is found only in still water. The cases are smooth cylinders formed of pieces of leaves. The pupæ are usually to be found in protected situations. I have found them most often imbedded in soft wood under the bark of decayed logs. As many as twenty-five cases were taken in a piece of white birch 2½ in. in diameter by 6 in. long.

It will be noted that as far as this material goes and it may be considered typical, the first two species, namely those which live in the most rapid streams, are the only ones among those having exposed cases which firmly anchor their larval cases. The last two, namely those characteristic of still water, are also the two which build their cases of the lightest, most easily floated material. The species of *Polycentropus* build in the mud or sand of the bottom and since there is more loose material, mud, etc., to be found where the current is weakest and since the exposed tips of the cases would be liable to be broken in the swift current, they find their best home in water having slight or no motion. In other words, I believe that the distribution of the larvæ of Trichoptera is strongly influenced by the adaptation of their cases to the strength of the current.

Of course, other factors have influence, but they do not seem to be as important as the strength of the current. As an example of the way these other factors work, it might be noted that although *Platycentropus maculipennis* is typically found in still water, it occurs in even a strong current if there be an abundance of vegetation to which it can cling.

As another example, *Molanna cinerea* Hagen is found only where there is slimy ooze on the bottom, but it is not found where there is a slimy ooze if there is no current or if the current be at all strong. As a matter of fact, we can, by a glance at Fig. —, make a fairly safe prediction as to which of these species will be found in a given environment—that is, a given environment in northern New Jersey.